History of the Development of the Nematology Program at the California Department of Food and Agriculture

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A historical account of the development of the Nematology Program at the California Department of Food and Agriculture requires at least in part, an understanding of the corresponding development and organization of the Department, and therein, certain regulatory programs that necessitated the establishment of the State Nematology Laboratory.

Establishment of the Department:

On April 15, 1880, an act for the formation of the viticulture industry of the state provided for the appointment of a Board of Viticulture Commissioners. In 1881, another act enlarged the duties of powers stating the appointment of two positions namely, a viticulture health officer and a horticulture health officer, created specifically to deal with grape phylloxera issues. In 1882, county boards were appointed in the twenty-one counties of California.

In 1883, the State Board of Horticulture was created. Legislation was amended in 1903 to replace the State Board of Horticulture with a State Commissioner of Horticulture. However, in 1919, the office of State Commissioner of Horticulture was abolished, and instead, legislature created the State Department of Agriculture, which was presided over by a Director of Agriculture.

Organization of the Department:

The organization of the California Department of Agriculture (CDA) included the Divisions of Animal Health and Plant Industry. The latter comprised the Bureau of Entomology, Bureau of Plant Pathology, Bureau of Plant Quarantine and Bureau of Chemistry plus Nursery Service, Weed and Vertebrate Pest Control units. In about 1922, D. G. Milbrath was appointed the first chief of the Bureau of Plant Pathology. He was a "first generation" protégé of Nathan A. Cobb, the “Father of Nematology” in the USA. The Bureau of Plant Pathology dealt with nematology and plant pathology. Since then the names of the Department and its various sectors have changed following administrative and operational reorganization.

In 1971, the Division of Plant Industry was reorganized so that the Bureau of Plant Pathology became known as the "Laboratory Services Program Unit" and now contained entomology, nematology, and plant & seed taxonomy laboratories. In 1974, the Department became the "Department of Food and Agriculture" (CDFA). Laboratory Services was renamed as the "Analysis and Identification" branch in 1982, which in turn became the "Plant Pest Diagnostics Branch" in 1996 continuing to comprise of plant

pathology, entomology, nematology, seed, and botany laboratories. In 1998, the Division of Plant Industry was renamed as "Plant Health and Pest Prevention Services".

Development of Nematology and other related programs:

During the early 1920s, various plant parasitic nematodes, now commonly known, were being discovered as serious pests of agricultural crops in California. Reports of crop damage caused by certain plant parasitic nematodes were already making headline news nationally and globally. These discoveries in California led to further investigative surveys to determine the extent of establishment of the nematode species within the state, and subsequent actions necessary to eliminate and/or control potential problems. Specific events in California included the discovery of the Citrus Nematode, *Tylenchulus semipenetrans* as a problem on citrus by Los Angeles County Agricultural Inspector J. R. Hodges. In the early 1920's surveys were conducted for the Stem and Bulb Nematode, *Ditylenchus dipsaci*. The Root Lesion Nematodes, *Pratylenchus* spp. were first reported parasitic on fig roots in California in 1927, and on apple roots in 1938.

A. The "Pinto Tag" Program

Plant parasitic nematodes as pests of nursery stock were becoming problematic. The "Pinto Tag" program was initiated in 1943, and provided that nursery stock meeting strict standards of cleanliness may be shipped within the State without destination inspection. The program was voluntary for nursery participants, however, plant parasitic nematode pests were soon to become a major hindrance to the effectiveness of the program.

B. The "Pest Rating" System

In 1951, the Joint Legislative Committee on Agriculture and Livestock Problems held hearings at which the Department of Agriculture and the University of California reviewed the status of the nematode situation, and produced the first distribution records of plant parasitic nematodes in California. Recommendations for intensified research efforts were made at that time. It is perhaps, in the early 1950's that a pest rating system was established by the State Department Bureau of Entomology and in the late 1950's was adopted by the Bureau of Plant Pathology. The pest rating system was primarily for agricultural commissioners as an evaluation of the statewide importance of particular pest species (including nematodes) and the subsequent actions to be administered. The rating classification of nematodes was (first?) revised in 1964 and thereafter, periodically revised to date.

C. Further pest detections: the Root Lesion Nematodes

By the early 1950's the Root Lesion Nematodes, *Pratylenchus* spp. were found in numerous orchards and field crops within the State. Prior to Sher and Allen's (University of California) revision of the genus, many problems were encountered by the State

Department in trying to restrict the spread of the nematode because of a confusing taxonomy and limited knowledge on distribution and host range of the species.

In 1951, W.H. Hart was employed as the Bureau's first nematologist. [D.G. Milbrath retired, and G.L. Stout became Chief of the Bureau of Plant Pathology.]

As a result of legislative action in 1947 a system of pest detection was established in the Division of Plant Industry. Three entomologist and three plant pathologist positions were authorized to survey for insects and plant diseases not known to occur in the state, or in the U.S., or of limited distribution in California. At that time the program was called 'permanent survey'. In the Bureau of Plant Pathology the plant pathologists in permanent survey were also involved in nematological survey.

D. The Burrowing Nematode and the Quarantine Program

In 1953, the identification of the Burrowing Nematode, *Radopholus similis,* as the cause for spreading decline of citrus in Florida gave sufficient cause to the California Department of Agriculture to protect California against this devastating nematode pest. In 1954, S. A. Sher (University of California Riverside) gave a first report of *R. similis* in California. The nematode species was found infesting banana in a Los Angeles nursery. Consequently, the need for establishing the presence or absence of the nematode species in California was realized along with the necessity to protect the State against the introduction of exotic nematode pests. In 1954-56 a state-county survey revealed several ornamental host plants in nurseries to be infested with *R. similis*. Eradicative measures were pursued.

In 1956, an exterior quarantine was established by CDA against the Burrowing Nematode. This quarantine is maintained to date. From 1956 to 1964 several surveys were conducted for the nematode pest in California: In 1956, USDA organized a nationwide survey of citrus producing areas. In California, surveys of citrus and avocado orchards, and ornamental nursery stock were conducted through the cooperative efforts of federal, state and county agencies. From 1956 to 1963 no organized surveys were conducted, however, some counties conducted their own sampling schemes. In 1963 CDA, federal and county officials conducted intensive statewide surveys of Anthurium plants. The ultimate outcome of these investigations was that the Burrowing Nematode was not established in California. In 1964, CDA created the Burrowing Nematode Detection program for California nurseries.

During those early years, and currently continuing, members of County Agricultural Commissioner’s offices carried out much of the frontline nematode detection work as collaborators in the State’s regulatory nematology program.

E. Inspection Program

In the mid 1950′s, with the establishment of the Burrowing Nematode Quarantine, county agricultural commissioners realized that regulatory actions against nematodes could not be based on visual inspection of plant commodities alone. Subsequently, many counties set up their own laboratories for the extraction and identification of nematodes. This provided intensive laboratory inspection of nurseries, which in turn resulted in many unsuspected problems. California-grown nursery trees, fruit tree seedlings and strawberries were found infested with Root-lesion and Root-knot nematodes. In addition, heavy infestations of the Foliar Nematode were found in California strawberry nurseries. These newly discovered infestations led to plants being rejected by some counties. However, discrepancies arose causing major problems when other counties accepted the plants based on visual inspection alone. In 1956, CDA convened a new study committee, chaired by G.L. Stout to address problems encountered by counties in the inspection of quarantine nursery plants for nematodes. A statewide inspection program was developed for strawberry nursery stock. This program subsequently became the model for inspections systems.

The newly developed inspection program resulted in excessive sample loads, which were too much for the state laboratory to handle without a large staff and expanded facilities. As a result, a system for nematode sample processing was developed and conducted at the county laboratories under the guidance of W.H. Hart. Preserved nematodes in suspension were submitted to the state laboratory for identifications made by state nematologists. Forty out of fifty-eight counties participated by establishing nematology laboratories and personnel trained in nematode extraction and identification.

F. The Nematode Control Program and Nematode Study Committee

In spite of increased shared efforts by state and counties in handling nematode samples, during 1957-59, the sudden change from visual inspection to laboratory methods for nematode detection in nursery, and intra-and interstate quarantine shipments continued to result in considerable concern for California nurserymen as well as those from several other western states. This concern led to the eventual development and establishment of the State Department's nematode control policies and permanent Nematode Study Committee.

On April 14, 1959, representative nurserymen from Oregon, Washington and California met with personnel from the California Department of Agriculture, University of California nematologists, County Agricultural Commissioners and others in Sacramento. As a result of this meeting, the representative nurserymen developed and approved a resolution for the State Department to facilitate the movement of nursery stock and quarantine shipments. This resolution was deemed necessary because of the problems encountered with a confusing taxonomy of the Lesion Nematodes that hindered and/or delayed timely identifications, the lack of information for effective nematode

control, the lack of uniformity of inspection among county agricultural commissioners, and the fact that it took at least three years to grow many types of nursery stock. Requests were made for 1) a State-approved method for soil treatment which under proper supervision and guidelines would render nursery stock certified if grown in treated soil, without the need for laboratory inspection; 2) a nematode study committee to further study the problems mentioned above.

Immediately following the April 14 meeting, a permanent nematode study committee was formed at the request of the Director of Agriculture. The committee comprised of two members each from the Department of Agriculture, the University of California, County Agricultural Commissioners, and the Chemical Industry. Three members represented the Nursery Industry, of which one member was from the California Strawberry Nursery Association. The Committee was designed to serve solely as an advisory group, without official capacity, to the State Department of Agriculture and County Agriculture Commissioners.

The first meeting of the Nematode Study Committee was held on June 25, 1959, with W. F. Hiltabrand, Chief, Bureau of Nursery Service elected as Chairman. At this meeting, the Committee as a starting point for a certification program accepted the recommendations made by nematologists, D. J. Raski and W. H. Hart for "Proposed Methods of Soil Treatment for Nematode Control in Woody Plant Nursery Growing Grounds". This motion was presented to the Quarantine and Nursery Committee of the California State Association of County Agricultural Commissioners, and to nurserymen through the California Association of Nurserymen. The Committee emphasized that the motion was not intended to preclude laboratory methods for nematode detection and identification. In fact, laboratory methods were recognized as necessary for quarantine inspection and determining the distribution of plant parasitic nematodes throughout the state. The value of clean, plant parasitic nematode-free nursery stock was emphasized.

Subsequent to the motion presented by the Nematode Study Committee, in 1960, "The Approved Treatment and Handling Procedures for the Control of Nematodes in Deciduous Fruit and Nut Tree, Grapevine, Berry and Vegetable Plant Growing Ground" were adopted by CDA as a requirement for qualification for use of Intercounty Nursery Stock Certificates, "Pinto Tags". This was a voluntary inspection program, and G. L. Stout and W. H. Hart were leaders in developing and implementing the program. This program required acre-by-acre sampling at 40 x 40 foot intervals, and laboratory examination for nematodes. Sampling requirements were waived if the planting land site had met CDA's specifications for high-dosage fumigation along with specified pre-treatment and post-treatment practices.

In 1961, a special committee of County Agricultural Commissioners and CDA personnel developed a pattern for the current Nematode Control Program. This committee, under the chairmanship of Harold A Crane, Agricultural Commissioner of San Bernardino County, successfully set a target date of 1965 to inspect all commercial varieties of deciduous and non-deciduous fruit trees, nut trees, grapevines, berry and vegetable plants for commercial planting. This mandatory nursery inspection was

combined with the voluntary "Pinto Tag" program. This new regulation required inspection for nematodes using laboratory methods except where plants had been grown in grounds treated in accordance with the Approved Treatment and Handling Procedures of CDA, under the supervision of the County Agricultural Commissioner. By 1969, the success of the Nematode Control Program in reducing the occurrence of plant parasitic nematodes in nursery stock for farm planting was evident. Less than one percent of the acreage was infested with plant parasitic nematodes of concern in more than 2,200 acres of fruit and nut tree, grapevine, berry and vegetable plant nursery stock.

G. Further Surveys

From 1958 onwards, several statewide surveys for the Golden Nematode, *Globodera rostochiensis*, were conducted by federal, state and county agencies, resulting in negative findings.

Between 1958 and 1963, several surveys were conducted by CDA for the detection of the Sugarbeet Cyst Nematode, *Heterodera schactii.*

In 1964, the origin inspection program was made mandatory.

H. The Seed Garlic Certification Program

In 1965, the State Department's Nursery Service set the seed garlic certification program in place. Seed garlic was certified if inspected and found free from Stem and Bulb Nematode, *Ditylenchus dipsaci* and White rot fungus.

The California Department of Food and Agriculture's Nematologists:

Soon after W. H. Hart was employed as the first nematologist of the Bureau of Plant Pathology in 1951, the following persons were also employed to work under him at the nematology laboratory: J. R. Breece (left CDA 1959), S. Ayoub (joined 1957, left 1986) and N. E. El Gholl (joined 1958, left 1960's). W. H. Hart left CDA for the position of Extension Nematologist at the University of California Agricultural Extension Services at Davis.

Changes in administrative leadership in the Division and Bureau/Branch occurred over time and are briefly mentioned here as landmarks in the employment of state nematologists. G. E. Allstat succeeded G. L. Stout in the early 1960's as Chief of the Bureau, and C. W. Nichols succeeded G. E. Allstat for the same position during 1965-71. G. Okumura was appointed the first Chief of Laboratory Services, and a Program Supervisor headed each discipline.

During the early 1960's, the State Department's field office in Riverside was closed down and several staff was transferred to the Sacramento main office. A. M. French was amongst those transferred, and became Program Supervisor for Nematology. The nematologists under A. M. French included: S. Ayoub, D. E. Konicek (joined late

1960's, left 1991), A. C. Weiner (joined 1960, left 1997), E. Hasbrouck (joined 1967-68, left the Nematology Laboratory in 1972), I. A. Siddiqui (joined 1969). A. M. French became Principal Staff Plant Pathologist/Nematologist in the mid 1970's and left the Department in 1985. I. A. Siddiqui transferred out of the Nematology Laboratory to the Control and Eradication Unit in 1975, became Chief of Special Services and Pest Detection in 1982, promoted to Assistant Director of the Division of Plant Industry in 1985, and left the Department in 1997.

In the years that followed, other nematologists that joined the Nematology Laboratory were: R. T. Robbins (joined 1972, left 1979), R. W. Hackney (joined 1975), R. Fortuner (joined 1980 left 1993), J. J. Chitambar (joined 1986, left 1992, rejoined 1993) and K. Dong (joined 1999).

The nematologists currently working at CDFA's Nematology Laboratory are: J. J. Chitambar, Ph.D., Senior Plant Nematologist (Specialist), R. W. Hackney, Ph.D., Senior Plant Nematologist (Specialist), and K. Dong, Ph. D., Associate Plant Nematologist, under the Division leadership of D. Henry, and Branch leadership of D. Mayhew.

Current Status of the State's Nematology Program and Laboratory:

The foundation for keeping California's agriculture clean by regulating the entrance, establishment, increase and spread of unwanted economically important plant parasitic nematodes has been historically set in place at the California Department of Food and Agriculture. Many nematology related state programs are still in operation to date, including the External Quarantine Burrowing Nematode and Reniform Nematode program, the Nursery Nematode Control program, Nursery Stock Certification program, Seed Garlic and Strawberry Phytosanitary Certification program, and the Quarantine Phytosanitary Certification program for export trade California grown commodities. Many of these programs have increased volumetrically over the decade largely due to increased human populations and migration to California. As a result there have been increases in quantities, quality and types of plant quarantine shipments with their associated parasites entering California, as well as increased demands for clean nursery stock and other plant commodities for local, national and international commerce. There has also been a decrease or arrest of certain programs: the Nursery Burrowing Nematode Detection program was terminated in 1994 as the pest risk potential did not justify the economic costs and work load. However, with the increase in agricultural trade locally, nationally and globally, and the lessened availability of certain pesticides effectively used in pre-plant soil fumigation, post-plant nematode management, and quarantine treatments, there is also an increased demand for information on diagnostics, distribution, biology, economic impact of many new and old nematode species in California. During the past decade alone, certain nematode species as, the Sting Nematode (*Belonolaimus longicaudatus*), and the White-tip of Rice Nematode (*Aphelenchoides besseyi*), have presented detection, containment and eradication challenges to the State's quarantine and international trade programs.

The State's regulatory nematode detection program would virtually be ineffective without the continued essential collaboration of County Agricultural Commissioners and their staff. Indeed, most frontline detection and sample collection is done by the counties. Currently, while all counties participate in the nematode detection program, at least five counties have Plant Pathologist/Nematologist staff with nematode sample processing laboratories consistent in standard with the State Nematology Laboratory.

The Nematology Laboratory continues to play a vital role in the State's regulatory program by providing timely and accurate nematode diagnostics, as the basis by which regulatory action is taken against unwanted nematode pests. To this end, the responsibilities of the nematologists are , in the very least, four-fold:

1. *Nematode Diagnostics*. Regulatory samples are processed and analyzed at the laboratory for nematode diagnoses. Samples represent a major program namely, quarantine, nursery, commercial, or dooryard/residential, or a minor program as invertebrate nematode parasites, insect parasites and free-living nematodes. Over 300,000 nematode samples have been processed and diagnosed at the Nematology Laboratory from 1966 to 2000. Diagnostics involve the use of traditional morphological means supplemented when necessary, with molecular analyses, electron microscopy, computer-aided identification programs, biological assays, literature reviews and peer consultations.

2. *Professional consultation services*. State nematologists are often called to serve as consulters providing professional technical input to CDFA, other state, federal, industry and county agricultural agencies, often as collaborators with them on nematological and policy issues. Professional assistance is also available to private citizens.

3. *Training and education*. Training in regulatory nematology procedures, nematode biology, diseases, sampling, processing and nematode identification is provided primarily to county and state officials, as well as other interested parties. In addition, nematologists are responsible for organizing and participating in professional meetings, workshops, and other educational programs.

4. *Research*. Each nematologist conducts research in nematode taxonomy, methodologies, and other areas of concern in regulatory nematology.

The challenges in regulatory nematology have not been faced by the State Department alone. History has proven, and the present reveals that the challenges in regulatory nematology undoubtedly affect and include all participants of California Agriculture in universities, nurseries, chemical industries, County agricultural offices, federal, private companies, and growers.